DEPARTMENT OF THE INTERIOR
CANADA
HON. W. J. ROCHE, *Minister.* W. W. CORY, C.M.G., *Deputy Minister.*

# PUBLICATIONS

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# Dominion Observatory

## OTTAWA

BIBLIOTHEQUE DE L'ECOLE POLYTECHNIQUE DE MONTREAL

W. F. KING, C.M.G., LL.D., *Director.*

Vol. I, No. 13

# Orbit of ξ Persei from the *H* and *K* Lines

BY

J. B. CANNON, M. A.

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# Orbit of ξ Persei from the *H* and *K* Lines

(xsi)

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# ORBIT OF $\xi$ PERSEI FROM THE *H* AND *K* LINES.

BY J. B. CANNON, M.A.

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$\xi$ Persei is one of those stars in which the velocities given by the *H* and *K* lines of calcium differ greatly from those from the broad lines of hydrogen and helium. The spectrum is placed by Miss Cannon in the Oe5B class. The lines showing are those of hydrogen, helium and calcium. A few iron lines appear, but not with sufficient frequency to make them useful for measurement. The hydrogen and helium lines are very broad and ill-defined, the latter lines especially being very poor. The calcium lines are fairly good, sometimes both being easily measurable, sometimes only one and in some cases neither appears sufficiently defined to make measurement possible.

The first published measures of this star appeared in the Astrophysical Journal, Vol. XVIII., p. 383, 1903, five measures being given of the broad lines in an article by Professor Frost under the heading—"An Orion Star of Great Radial Velocity." The range (9 kilometres) was not considered sufficient ground to pronounce it a binary. Later in the Astrophysical Journal, Vol. XXIX., p. 236, 1909, Professor Frost announced another measure of this star giving a range of 30 kilometres. In that note he remarked that the *H* and *K* lines have a moderate positive velocity with a range of about 25 kilometres, these lines differing greatly in the velocities shown from the values derived from the broad lines.

Observations on the star were first made here in 1908, a few plates being taken. It was then dropped from the observing list until 1910, and

plates were taken in the seasons of 1910-11 and 1911-12. Although the broad lines were measured at first,—where measurement was possible,—as well as $H$ and $K$, it was not felt that these diffuse lines would be of any aid in ascertaining anything in regard to the orbit of the star, and attention was given almost exclusively to the $H$ and $K$ lines of calcium. These lines were not always found on the plates, but generally one or other of them was well enough defined to be measured. Of the 1908 plates only two gave measures of $K$ which were considered reliable. Of the later plates, 1910-11-12, 41 plates were good enough to be useful in the determination of the orbit. The later plates were all Seed 23 and were much better than the earlier ones of Seed 27, although the fine-grained plate did not serve to make the broad lines measurable. As stated above, these broad lines were measured at first. An attempt was also made to get measures on the members of the second series of hydrogen with a view to determining the wave-lengths of these lines in this star, but the utter impossibility of anything definite in this regard led to the abandonment of the attempt.

The wave-lengths used for $H$ and $K$ were 3968·625 and 3933·825 respectively. $K$ was, with very few exceptions, stronger than $H$. Some plates were found in which $H$ and $K$ gave widely different results. In such a case, if the lines were equally good, the plate was left out of consideration: if one was much better than the other that line was used.

Great aid was given in the work by the use of Yerkes measures of ten plates kindly sent me by Professor Frost, and of nine more plates loaned by Professor Frost and measured by me. As a check on the measures of a plate, here and at Yerkes, two plates IB141 and IB402 were measured at both places. On one of these, IB402, the measures were practically the same, but on the other, not too well-defined, a difference of ten kilometres was found. Of the nine plates taken at Yerkes and measured here, unfortunately four of them gave $H$ and $K$ differing considerably, while one of them gave only $H$ measurable. Otherwise the Yerkes plates fit the accepted curve as well as can be expected from a spectrum which gives only one and at most two lines on which to base results.

Table I. gives Yerkes plates measured at Yerkes; Table II. Yerkes plates measured by Cannon; and Table III. gives Ottawa observations.

TABLE I.

YERKES OBSERVATIONS—MEASURED AT YERKES.

| Plate. | Observer. | Date. | Exposure. | Julian Day. | Phase. | Lines. | Vel. | Wt. | O-C. |
|---|---|---|---|---|---|---|---|---|---|
| IB | | 1903 | | | | | | | |
| 101 | ...... | Sept. 26... | .......... | 2,416,384·86 | 6·371 | ............ | + 23 | ...... | + 4·5 |
| 119 | ...... | Oct. 16.... | .......... | 404·81 | 5·468 | ............ | + 29 | ...... | + 6·2 |
| 141 | ...... | Oct. 23... | .......... | 411·78 | 5·487 | ............ | + 6 | ...... | −16·6* |
| 179 | ...... | Nov. 7..... | .......... | 426·79 | 6·595 | ............ | + 10 | ...... | − 6·7 |
| 203 | ...... | Dec. 1..... | .......... | 450·66 | 2·661 | ............ | + 23 | ...... | +11·4 |
| 232 | ...... | Dec. 27.... | .......... | 476·50 | 0·697 | ............ | + 10 | ...... | + 0·5 |
| | | 1904 | | | | | | | |
| 304 | ...... | April 15... | .......... | 586·60 | 6·532 | ............ | + 24 | ...... | + 6·7 |
| 402 | ...... | Sept. 30... | .......... | 754·93 | 1·087 | ............ | + 2 | ...... | − 6·1 |
| 465 | ...... | Dec. 30.... | .......... | 845·56 | 1·354 | ............ | + 12 | ...... | + 4·3 |
| | | 1906 | | | | | | | |
| 821 | ...... | Aug. 10.... | .......... | 2,417,433·89 | 5·800 | ............ | + 23 | ...... | + 1·5 |

*Cannon's Measure, +16, Residual −6·6.

TABLE II.

YERKES PLATES—MEASURED BY CANNON.

| Plate. | Observer. | Date. | Exposure. | Julian Day. | Phase. | Lines. | Vel. | Wt. | O-C. |
|---|---|---|---|---|---|---|---|---|---|
| IB[2] | | 1906 | | | | | | | |
| 850 | ...... | Sept. 14... | .......... | 2,417,468·90 | 6·055 | *K* | + 14·5 | ·2 | − 6·0 |
| 879 | ...... | Oct. 12.... | .......... | 496·84 | 6·201 | *K* | + 4·5 | ·2 | −15·0 |
| | | 1907 | | | | | | | |
| 935 | ...... | Jan. 4..... | .......... | 580·56 | 6·499 | *K* | + 19·3 | ·5 | + 1·8 |
| 1199 | ...... | Oct. 11.... | .......... | 860·81 | 1·758 | *K* | − 0·5 | ·5 | − 8·3 |
| 1208 | ...... | Oct. 18.... | .......... | 867·75 | 1·747 | *K* | − 5·9 | ·5 | −13·7 |
| 1216 | ...... | Oct. 20.... | .......... | 869·76 | 3·757 | *H* & *K* | + 12·3 | 1·5 | − 6·2 |
| 1260 | ...... | Nov. 30.... | .......... | 910·68 | 2·971 | *H* | + 3·4 | ·5 | − 9·9 |
| 1289 | ...... | Dec. 16.... | .......... | 926·58 | 4·969 | *K* | + 7·9 | 1·0 | −15·3 |
| | | 1908 | | | | | | | |
| 1350 | ...... | Jan. 20.... | .......... | 961·51 | 5·144 | *K* | + 18·6 | 1·0 | − 4·6 |

Remarks:— 1199, 1208 — *H* and *K* differ.
1289 — *H* is highly + ve.
1350 — *H* is much more + ve.

## TABLE III.

### OTTAWA OBSERVATIONS OF ξ PERSEI.

| Plate. | Observer.* | Date. | Exposure. | Julian Day. | Phase. | Lines. | Vel. | Wt. | O-C. |
|---|---|---|---|---|---|---|---|---|---|
| | | 1908 | m. | | | | | | |
| 1974 | P¹ | Nov. 20 | 60 | 2,418,266·83 | 4·620 | *K* | + 18·0 | ·5 | − 4·7 |
| 1999 | C | Dec. 4 | 40 | 280·72 | 4·613 | *K* | + 26·0 | ·2 | + 3·4 |
| | | 1910 | | | | | | | |
| 3740 | C | Oct. 10 | 62 | 957·83 | 0·522 | *H & K* | + 10·3 | 1·5 | − 0·3 |
| 3765 | C | Oct. 19 | 85 | 964·81 | 0·555 | *K* | + 4·9 | ·5 | − 5·4 |
| 3777 | P | Oct. 25 | 45 | 970·91 | 6·653 | *H & K* | + 16·0 | 1·5 | − 0·3 |
| 3817 | C | Dec. 5 | 60 | 9,011·61 | 5·653 | *H & K* | + 36·0 | ·7 | +13·8 |
| 3861 | C | Dec. 12 | 76 | 018·68 | 5·763 | *H & K* | + 22·0 | 1·2 | + 0·2 |
| 3881 | P¹ | Dec. 16 | 42 | 022·79 | 2·922 | *K* | + 14·2 | ·5 | + 1·0 |
| | | 1911 | | | | | | | |
| 3915 | P | Jan. 5 | 40 | 042·54 | 1·822 | *H & K* | + 7·5 | 1·2 | − 0·4 |
| 3921 | C | Jan. 9 | 43 | 046·54 | 5·823 | *K* | + 35·5 | 1·0 | +13·9 |
| 3929 | P | Jan. 12 | 65 | 049·55 | 1·882 | *K* | + 2·7 | ·5 | − 5·5 |
| 3936 | C | Jan. 16 | 48 | 053·58 | 5·913 | *K* | + 24·7 | ·7 | + 3·6 |
| 3957 | P¹ | Jan. 18 | 45 | 055·57 | 0·952 | *K* | + 7·3 | ·5 | − 1·2 |
| 3962 | P | Jan. 19 | 60 | 056·58 | 1·962 | *H & K* | + 3·1 | 1·2 | − 4·9 |
| 3974 | C | Jan. 30 | 60 | 067·66 | 6·083 | *K* | + 16·2 | ·2 | − 4·1 |
| 3991 | H | Feb. 10 | 50 | 079·56 | 4·083 | *K* | + 13·3 | 1·0 | − 7·0 |
| 4020 | C | Feb. 27 | 55 | 091·58 | 2·202 | *K* | + 15·0 | 1·0 | + 5·8 |
| 4056 | C | Mar. 6 | 50 | 102·50 | 6·173 | *K* | + 16·5 | ·5 | − 3·2 |
| 4067 | H | Mar. 7 | 50 | 103·52 | 0·242 | *K* | + 5·4 | ·5 | − 6·9 |
| 4552 | C | Sept. 13 | 55 | 293·89 | 2·932 | *K* | + 4·3 | ·2 | − 8·9 |
| 4634 | P¹ | Oct. 12 | 60 | 322·77 | 4·113 | *K* | + 17·4 | 1·0 | − 3·3 |
| 4645 | P¹ | Oct. 13 | 60 | 323·81 | 5·053 | *H & K* | + 30·5 | ·5 | + 7·2 |
| 4676 | P | Nov. 2 | 60 | 343·66 | 4·053 | *H & K* | + 25·1 | 1·0 | + 4·8 |
| 4685 | P¹-C | Nov. 3 | 59 | 344·74 | 5.133 | *K* | + 15·8 | ·5 | − 7·4 |
| 4690 | C | Nov. 10 | 62 | 351·71 | 5·143 | *K* | + 16·8 | 1·0 | − 6·4 |
| 4715 | P¹ | Dec. 6 | 67 | 377·59 | 4·303 | *K* | + 25·7 | ·2 | + 4·2 |
| 4729 | H | Dec. 19 | 40 | 390·60 | 2·332 | *K* | + 5·4 | ·7 | − 4·4 |
| 4738 | H | Dec. 25 | 40 | 396·70 | 1·482 | *H & K* | + 15·5 | 1·0 | + 7·9 |
| | | 1912 | | | | | | | |
| 4745 | C | Jan. 1 | 55 | 403·58 | 1·402 | *K* | + 11·0 | ·2 | + 3·3 |
| 4758 | P¹ | Jan. 10 | 51 | 412·50 | 3·372 | *H & K* | + 16·8 | ·7 | + 0·8 |
| 4759 | P¹ | Jan. 10 | 49 | 412·53 | 3·375 | *K* | ...... | ...... | ...... |
| 4779 | C | Jan. 12 | 90 | 414·60 | 5·473 | *K* | + 18·5 | 1·0 | − 3·7 |

TABLE III.

OTTAWA OBSERVATIONS OF ξ PERSEI—*Concluded.*

| Plate. | Observer.* | Date. | Exposure. | Julian Day. | Phase. | Lines. | Vel. | Wt. | O-C. |
|---|---|---|---|---|---|---|---|---|---|
| | | 1912 | m. | | | | | | |
| 4801 | P[1] | Jan. 19........ | 93 | 2,419,421·62 | 5·543 | *H* & *K* | + 21·0 | 1·5 | − 1·6 |
| 4819 | H | Jan. 26........ | 93 | 428·56 | 5·533 | *K* | + 15·0 | 1·0 | − 7·6 |
| 4828 | C | Feb. 1.......... | 108 | 434·51 | 4·533 | *H* & *K* | + 21·8 | 1·2 | − 0·5 |
| 4831 | P | Feb. 10........ | 90 | 443·52 | 6·593 | *K* | + 21·2 | ·2 | + 4·4 |
| 4833 | P | Feb. 12........ | 90 | 445·55 | 1·672 | *H* & *K* | + 11·9 | ·7 | + 4·2 |
| 4839 | H | Feb. 13........ | 98 | 446·53 | 2·652 | *H* & *K* | + 7·3 | 1·0 | − 4·2 |
| 4843 | C | Feb. 14........ | 87 | 447·53 | 3·653 | *H* & *K* | + 21·6 | 1·2 | + 3·6 |
| 4849 | H | Feb. 20........ | 90 | 453·56 | 2·732 | *H* & *K* | + 14·0 | 1·2 | + 2·0 |
| 4853 | H | Feb. 23........ | 87 | 456·58 | 5·753 | *K* | + 17·8 | 1·0 | − 4·0 |
| 4858 | C | Feb. 28........ | 92 | 461·54 | 3·763 | *H* & *K* | + 21·6 | ·7 | + 2·9 |
| 4869 | H | Mar. 5.......... | 85 | 467·55 | 2·822 | *K* | + 14·2 | ·5 | + 1·7 |
| 4874 | C | Mar. 6.......... | 89 | 468·55 | 3·813 | *K* | + 15·6 | ·5 | − 3·2 |

***P=Plaskett, H=Harper, P[1]=Parker, C=Cannon.**

MEASURES OF ξ PERSEI.

Yerkes Plates.

| λ | IB² 850 | | IB² 879 | | IB² 935 | | IB² 1199 | | IB² 1208 | | IB² 1216 | | IB² 1260 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ........ | .... | ........ | .... | ........ | .... | ........ | .... | ........ | .... | − 3·26 | 1 | + 6·05 | ⅓ |
| 3933·825 | − 12·16 | ½ | − 15·18 | ⅓ | + 38·05 | ⅓ | − 20·54 | ⅓ | − 23·44 | ⅓ | − 6·05 | ⅓ | ........ | .... |
| Weighted mean | − 12·16 | | − 15·18 | | + 38·05 | | − 20·54 | | − 23·44 | | − 4·19 | | + 6·05 | |
| $V_a$ | + 26·96 | | + 19·89 | | − 18·74 | | + 20·24 | | + 17·69 | | + 16·90 | | − 2·47 | |
| $V_d$ | + ·04 | | + ·02 | | + ·11 | | + ·07 | | + ·14 | | − ·07 | | + ·07 | |
| Curv. | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | |
| Radial Velocity | + 14·5 | | + 4·45 | | + 19·3 | | − 0·5 | | − 5·9 | | + 12·3 | | + 3·4 | |

MEASURES OF ξ PERSEI—*Continued.*

Yerkes Plates.

| λ | IB$^{3}$ 1289 | | IB$^{3}$ 1350 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ........ | .... | ........ | .... | ........ | .... | ........ | .... | ........ | .... | ........ | .... | ........ | .... |
| 3933·825 | + 18·46 | 1 | + 43·91 | 1 | ........ | .... | ........ | .... | ........ | .... | ........ | .... | ........ | .... |
| Weighted mean | + 18·46 | | + 43·91 | | | | | | | | | | | |
| $V_a$ | − 10·38 | | − 24·11 | | | | | | | | | | | |
| $V_d$ | + ·14 | | + ·11 | | | | | | | | | | | |
| Curv. | − ·30 | | − ·30 | | | | | | | | | | | |
| Radial Velocity | + 7·9 | | + 18·6 | | | | | | | | | | | |

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates.

| λ | 1974 | | 1974* | | 1999 | | 1999* | | 3740 | | 3765 | | 3777 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ........ | .... | ........ | .... | ........ | .... | ........ | .... | − 6·27 | ½ | ........ | .... | + 5·58 | ½ |
| 3933·825 | + 17·31 | ½ | + 15·28 | ½ | + 32·94 | ¼ | + 29·07 | ¼ | − 10·73 | 1 | − 12·10 | ½ | + 1·66 | 1 |
| Weighted mean | + 17·31 | | + 15·28 | | + 32·94 | | + 29·07 | | − 9·24 | | − 12·10 | | + 2·97 | |
| $V_a$ | + 2·31 | | + 2·31 | | − 4·60 | | − 4·60 | | + 19·88 | | + 17·27 | | + 14·76 | |
| $V_d$ | − ·21 | | − ·21 | | − ·11 | | − ·11 | | − ·03 | | − ·03 | | − ·14 | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 19·1 | | + 17·1 | | + 28·0 | | + 24·1 | | + 10·3 | | + 4·9 | | + 17·3 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued*

Ottawa Plates.

| λ | 3777* | | 3817 | | 3817* | | 3861 | | 3861* | | 3881 | | 3915 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | – 3·52 | ½ | | | | | | | + 35·19 | 1 | | | + 26·20 | ½ |
| 3933·825 | + 2·16 | 1 | + 36·86 | ½ | + 41·3 | ½ | + 28·95 | ½ | + 23·97 | ½ | + 25·13 | ½ | + 19·55 | ¼ |
| Weighted mean | + 0·27 | | + 36·86 | | + 41·30 | | + 28·95 | | + 32·94 | | + 25·13 | | + 23·98 | |
| $V_a$ | + 14·76 | | – 5·02 | | – 5·02 | | – 8·52 | | – 8·52 | | – 10·51 | | – 19·14 | |
| $V_d$ | – ·14 | | – ·05 | | – ·05 | | – ·04 | | – ·04 | | – ·16 | | – ·02 | |
| Curv. | – ·28 | | – ·28 | | – ·28 | | – ·28 | | – ·28 | | – ·28 | | – ·28 | |
| Radial Velocity | + 14·7 | | + 31·5 | | + 36·0 | | + 20·0 | | + 24·1 | | + 14·2 | | + 4·5 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued*.

Ottawa Plates.

| λ | 3915* | | 3921 | | 3929 | | 3936 | | 3957 | | 3957* | | 3962 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt | Vel. | Wt. |
| 3968·625 | + 27·74 | 1 | + 47·50 | ½ | | | | | | | | | + 30·15 | ½ |
| 3933·825 | + 34·69 | ½ | + 65·40 | ½ | + 24·63 | ½ | + 48·09 | ½ | + 34·20 | 1 | + 28·37 | ½ | + 26·71 | 1 |
| Weighted mean | + 30·05 | | + 56·40 | | + 24·63 | | + 48·09 | | + 34·20 | | + 28·37 | | + 27·40 | |
| $V_a$ | 19·14 | | – 20·64 | | – 21·69 | | – 23·01 | | – 23·62 | | – 23·62 | | – 23·91 | |
| $V_d$ | – ·02 | | – ·01 | | + ·02 | | – ·07 | | – ·04 | | – ·04 | | – ·07 | |
| Curv. | – ·28 | | ·28 | | – ·28 | | – ·28 | | – ·28 | | – ·28 | | – ·28 | |
| Radial Velocity | + 10·6 | | + 35·5 | | + 2·7 | | + 24·7 | | + 10·3 | | + 4·4 | | + 3·1 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates.

| λ | 3974 | | 3991 | | 4020 | | 4020* | | 4056 | | 4056* | | 4067 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ...... | ...... | ...... | ...... | ...... | ...... | | | | | | | | |
| 3933·825 | + 43·76 | ½ | + 42·10 | 1 | + 42·93 | 1 | + 45·84 | 1 | + 46·68 | ½ | + 45·01 | ½ | + 34·19 | ½ |
| Weighted mean | + 43·76 | | + 42·10 | | + 42·93 | | + 45·84 | | + 46·68 | | + 45·01 | | + 34·19 | |
| $V_a$ | − 27·05 | | − 28·38 | | − 28·96 | | − 28·96 | | − 28·47 | | − 28·47 | | − 28·36 | |
| $V_d$ | − ·20 | | − ·13 | | − ·21 | | − ·21 | | − ·13 | | − ·13 | | − ·19 | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 16·2 | | + 13·3 | | + 13·5 | | + 16·4 | | + 17·8 | | + 16·1 | | + 5·4 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates

| λ | 4552 | | 4634 | | 4634* | | 4645 | | 4645* | | 4676 | | 4676* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | + 9·96 | ½ | + 5·24 | ½ |
| 3933·825 | − 23·08 | ½ | − 4·81 | 1 | − 0·33 | 1 | + 10·11 | 1 | + 12·15 | 1 | + 16·56 | ½ | + 19·63 | 1 |
| Weighted mean | − 23·08 | | − 4·81 | | − 0·33 | | + 10·11 | | + 12·15 | | + 13·26 | | + 14·86 | |
| $V_a$ | + 27·64 | | + 19·99 | | + 19·99 | | + 19·62 | | + 19·62 | | + 11·43 | | + 11·43 | |
| $V_d$ | + ·02 | | + ·07 | | + ·07 | | − ·02 | | − ·02 | | − ·09 | | − ·09 | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 4·3 | | + 15·5 | | + 19·4 | | + 29·4 | | + 31·5 | | + 24·3 | | + 25·9 | |

*Check Measurement

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates.

| λ | 4685 | | 4865* | | 4690 | | 4690* | | 4715 | | 4715* | | 4729 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | | | | | | | | | | | ...... | | ...... | .... |
| 3933·825 | + 4·16 | ½ | + 6·32 | | + 8·64 | 1 | + 10·07 | 1 | + 31·86 | ¼ | + 30·87 | ¼ | + 18·22 | ¼ |
| Weighted mean | + 4·16 | | + 6·32 | | + 8·64 | | + 10·07 | | + 31·86 | | + 30·87 | | + 18·22 | |
| $V_a$ | + 10·94 | | + 10·94 | | + 7·63 | | + 7·63 | | − 5·38 | | − 5·38 | | − 11·75 | |
| $V_d$ | − ·05 | | − ·05 | | + ·07 | | + ·07 | | − ·02 | | − ·02 | | + ·06 | |
| Curv. | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | |
| Radial Velocity | + 14·8 | | + 16·9 | | + 16·1 | | + 17·5 | | + 26·2 | | + 25·2 | | + 6·2 | |

*Check Measurement

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates.

| λ | 4729* | | 4738 | | 4738* | | 4745 | | 4758 | | 4759 | | 4779 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ..... | | + 23·36 | ½ | + 27·57 | ½ | ........ | .... | + 51·63 | ¼ | + 36·16 | ½ | ........ | .. |
| 3933·825 | + 16·72 | ¼ | + 33·11 | ½ | + 35·86 | ½ | + 28·79 | ¼ | + 36·69 | ½ | + 31·70 | ½ | + 38·35 | 1 |
| Weighted mean | + 16·72 | | + 28·24 | | + 31·72 | | + 28·79 | | + 41·66 | | + 33·93 | | + 38·35 | |
| $V_a$ | − 11·75 | | − 14·62 | | − 14·62 | | − 17·56 | | − 20·90 | | − 20·90 | | − 21·63 | |
| $V_d$ | + ·06 | | − ·15 | | − ·15 | | + ·02 | | + ·10 | | + ·10 | | − ·07 | |
| Curv. | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | |
| Radial Velocity | + 4·7 | | + 14·2 | | + 16·7 | | + 11·0 | | + 20·6 | | + 12·9 | | + 16·4 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates

| λ | 4779* | | 4801 | | 4801* | | 4819 | | 4819* | | 4828 | | 4831 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ....... | | + 44·41 | ½ | + 40·45 | ⅓ | + 33·59 | ¼ | | | + 45·18 | ¼ | | |
| 3933·825 | + 42·52 | 1 | + 47·09 | 1 | + 45·84 | 1 | + 40·10 | 1 | + 42·93 | 1 | + 50·00 | 1 | + 54·83 | ¼ |
| Weighted mean | + 42·52 | | + 46·55 | | + 44·04 | | + 38·80 | | + 42·93 | | + 49·03 | | + 54·83 | |
| $V_a$ | − 21·63 | | − 23·87 | | − 23·87 | | − 25·71 | | − 25·71 | | − 26·99 | | − 28·36 | |
| $V_d$ | − ·07 | | − ·13 | | − ·13 | | − ·05 | | − ·05 | | ·00 | | − ·07 | |
| Curv. | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | | − ·30 | |
| Radial Velocity | + 20·5 | | + 22·3 | | + 19·8 | | + 13·8 | | + 16·9 | | + 21·8 | | + 26·1 | |

*Check Measurement.

MEASURES OF ξ PERSEI—*Continued.*

Ottawa Plates

| λ | 4831* | | 4833 | | 4833* | | 4839 | | 4843 | | 4849 | | 4853 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | ....... | .... | + 48·88 | ¼ | + 52·06 | ¼ | + 46·81 | ¼ | + 45·01 | ¼ | + 39·60 | ¼ | | |
| 3933·825 | + 45·00 | ¼ | + 32·95 | ½ | + 39·19 | ⅓ | + 33·61 | 1 | + 52·50 | 1 | + 44·43 | 1 | + 47·34 | 1 |
| Weighted mean | + 45·00 | | + 38·27 | | + 43·49 | | + 36·25 | | + 51·00 | | + 43·46 | | + 47·34 | |
| $V_a$ | − 28·36 | | − 28·56 | | − 28·56 | | − 28·64 | | − 28·73 | | 29·03 | | − 29·06 | |
| $V_d$ | − ·07 | | − ·12 | | ·12 | | − ·07 | | − ·10 | | ·16 | | − ·20 | |
| Curv. | − ·30 | | − ·30 | | ·30 | | − ·30 | | − ·30 | | ·30 | | − ·30 | |
| Radial Velocity | + 16·3 | | + 9·4 | | + 14·5 | | + 7·3 | | + 22·0 | | + 14·0 | | + 17·8 | |

*Check Measurement

MEASURES OF ξ PERSEI—*Concluded.*

Ottawa Plates.

| λ | 4858 | | 4869 | | 4874 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 3968·625 | + 46·47 | ¼ | | | | | | | | | | | | |
| 3933·825 | + 53·16 | ½ | + 43·18 | ½ | + 44·43 | ½ | | | | | | | | |
| Weighted mean | + 50·93 | | + 43·18 | | + 44·43 | | | | | | | | | |
| $V_a$ | − 28·93 | | − 28·48 | | − 28·38 | | | | | | | | | |
| $V_d$ | − ·16 | | − ·19 | | − ·20 | | | | | | | | | |
| Curv. | − ·30 | | − ·30 | | − ·30 | | | | | | | | | |
| Radial Velocity | + 21·6 | | + 14·2 | | + 15·6 | | | | | | | | | |

The period finally decided on after a great many trials was 6·951 days. There are some fairly large residuals but the probable error of an average plate is ±3·6, and that is very satisfactory when one considers that many values are dependent on one line which is not always very well defined.

The observations were grouped into eleven normals which appear in Table IV. (The phases are from the final *T*).

TABLE IV.

| No. | Julian Day. | Phase. | Velocity. | Weight. | Residual. |
|---|---|---|---|---|---|
| 1 | 2,419,342·88 | 3·893 | + 19·42 | 3·0 | + 0·19 |
| 2 | 040·51 | 4·550 | + 22·42 | 1·0 | + 0·19 |
| 3 | 347·99 | 5·123 | + 19·98 | 1·0 | − 3·22 |
| 4 | 349·25 | 5·543 | + 21·65 | 2·0 | − 0·98 |
| 5 | 141·66 | 5·803 | + 24·96 | 2·0 | + 3·26 |
| 6 | 082·24 | 6·433 | + 17·36 | 1·5 | − 0·62 |
| 7 | 8,988·36 | 0·472 | + 8·24 | 1·0 | − 2·57 |
| 8 | 9,300·21 | 1·322 | + 12·23 | 1·0 | + 4·65 |
| 9 | 128·76 | 1·852 | + 6·44 | 2·0 | − 1·48 |
| 10 | 302·20 | 2·412 | + 9·56 | 1·5 | − 0·44 |
| 11 | 367·68 | 2·942 | + 13·95 | 1·5 | + 0·85 |

Preliminary elements for the orbit follow:—

$$
\begin{aligned}
\text{Period} &= 6{\cdot}951 \text{ days} \\
e &= {\cdot}1 \\
\omega &= 150^\circ \\
K &= 7{\cdot}75 \text{ km.} \\
T &= 2{,}418{,}249{\cdot}349 \text{ J. D.} \\
\gamma &= +15{\cdot}92 \text{ km.}
\end{aligned}
$$

Observation equations were formed and a solution put through with the object of getting a closer approximation to the true values of the elements. The observation equations found were:—

TABLE V.

OBSERVATION EQUATIONS.

| No. | $x$ | $y$ | $z$ | $u$ | $v$ | $-n$ | Weight |
|---|---|---|---|---|---|---|---|
| 1 | 1 | + ·461 | − ·139 | + ·786 | − ·694 | + 0·080 | 3·0 |
| 2 | 1 | + ·786 | − ·878 | + ·439 | − ·396 | − 0·410 | 1·0 |
| 3 | 1 | + ·911 | − ·925 | + ·019 | − ·057 | + 3·000 | 1·0 |
| 4 | 1 | + ·881 | − ·519 | − ·303 | + ·218 | + 1·100 | 2·0 |
| 5 | 1 | + ·807 | − ·130 | − ·499 | + ·410 | − 2·780 | 2·0 |
| 6 | 1 | + ·446 | + ·839 | − ·896 | + ·840 | + 2·020 | 1·5 |
| 7 | 1 | − ·497 | + ·255 | − ·962 | + 1·066 | + 3·830 | 1·0 |
| 8 | 1 | − 1·064 | − 1·003 | − ·261 | + ·253 | − 4·560 | 1·0 |
| 9 | 1 | − 1·024 | − ·305 | + ·299 | − ·395 | + 1·550 | 2·0 |
| 10 | 1 | − ·699 | + ·727 | + ·740 | − ·812 | + 0·920 | 1·5 |
| 11 | 1 | − ·268 | + ·975 | + ·933 | − ·919 | − 0·110 | 1·5 |

in which,

$$
\begin{aligned}
x &= \delta\gamma \\
y &= \delta K \\
z &= K\delta e \\
u &= K\delta\omega \\
v &= \frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}}
\end{aligned}
$$

The resulting normal equations were:—

$$
\begin{array}{rrrrrr}
17\cdot5x & +2\cdot067y & -1\cdot064z & +1\cdot752u & -2\cdot105v & +6\cdot085=0 \\
 & 9\cdot554y & -1\cdot876z & -1\cdot495u & +1\cdot499v & +0\cdot180=0 \\
 & & 6\cdot789z & +0\cdot593u & -0\cdot553v & +5\cdot123=0 \\
 & & & 7\cdot230u & -6\cdot986v & -1\cdot242=0 \\
 & & & & 6\cdot848v & +1\cdot357=0
\end{array}
$$

Solving these equations the corrections to the various elements were found to be :—

$$
\begin{aligned}
\delta\gamma &= -\cdot52 \\
\delta K &= \pm\cdot00 \\
\delta e &= -\cdot11 \\
\delta\omega &= -22^\circ\cdot47 \\
\delta T &= -\cdot496 \text{ days.}
\end{aligned}
$$

There is one peculiarity about these corrections, viz., $\delta e$ has the value $-\cdot11$ whereas the preliminary value is only $\cdot1$. This would seem to indicate that the orbit is circular and $\omega$ indeterminate. This will be further seen from the oscillations in the value of $\omega$ in the following operations.

New preliminary values were taken in which,

$$
\begin{aligned}
e &= \cdot05 \\
\omega &= 60^\circ \\
K &= 7\cdot75 \text{ km.} \\
T &= 2{,}418{,}247\cdot607 \text{ J. D.} \\
\gamma &= 15\cdot06 \text{ km.}
\end{aligned}
$$

It might be stated here that the value of $\Sigma pvv$ was reduced by the least squares solution above, the corrected $e$ being taken as zero, from $74\cdot7$ to $73\cdot2$. With the new preliminary values, $\Sigma pvv$ was $72\cdot5$. It was apparent that any solution would fail to make much reduction in the value of $\Sigma pvv$, the signs being well distributed in the residuals. However a least squares solution was made with the new preliminary values.

The observation equations formed from the new preliminary values, using the same substitutions as before, were as follows:—

TABLE VI.

OBSERVATION EQUATIONS FROM SECOND PRELIMINARY VALUES.

| No. | $x$ | $y$ | $z$ | $u$ | $v$ | $-n$ | Weight. |
|---|---|---|---|---|---|---|---|
| 1 | 1 | + ·419 | − ·953 | + ·876 | − ·865 | − 1·120 | 3·0 |
| 2 | 1 | + ·847 | − ·634 | + ·525 | − ·564 | − 0·800 | 1·0 |
| 3 | 1 | + 1·023 | + ·392 | + ·016 | − ·062 | + 3·010 | 1·0 |
| 4 | 1 | + ·966 | + ·946 | − ·382 | + ·365 | + 0·890 | 2·0 |
| 5 | 1 | + ·849 | + 1·000 | − ·609 | + ·618 | − 3·320 | 2·0 |
| 6 | 1 | + ·359 | + ·147 | − ·986 | + 1·638 | + 0·480 | 1·5 |
| 7 | 1 | − ·561 | − ·998 | − ·853 | + ·844 | + 2·470 | 1·0 |
| 8 | 1 | − ·960 | + ·183 | − ·213 | + ·164 | − 4·620 | 1·0 |
| 9 | 1 | − ·935 | + ·882 | + ·237 | − ·261 | + 1·370 | 2·0 |
| 10 | 1 | − ·707 | + ·891 | + ·638 | − ·618 | − 0·160 | 1·5 |
| 11 | 1 | − ·352 | + ·252 | + ·883 | − ·837 | − 1·640 | 1·5 |

Normal equations resulting therefrom were:—

$$
\begin{aligned}
17\cdot 5x \ +2\cdot 316y \ +3\cdot 675z \ +1\cdot 397u \ -1\cdot 395v \ -7\cdot 400 &= 0\\
9\cdot 711y \ -0\cdot 071z \ -1\cdot 643u \ +1\cdot 639v \ -1\cdot 144 &= 0\\
10\cdot 972z \ -2\cdot 572u \ +2\cdot 547v \ -1\cdot 688 &= 0\\
7\cdot 735u \ -7\cdot 715v \ -3\cdot 459 &= 0\\
7\cdot 712v \ +3\cdot 283 &= 0
\end{aligned}
$$

Solving these, the corrections found were:—

$$
\begin{aligned}
\delta\gamma &= +\cdot 34 \text{ km.}\\
\delta K &= +\cdot 12 \text{ km.}\\
\delta e &= +\cdot 022\\
\delta\omega &= +81^\circ\cdot 80\\
\delta T &= +1\cdot 511 \text{ days.}
\end{aligned}
$$

whence the new values of the elements:—

$$\begin{aligned}
\gamma &= 15\cdot 40 \text{ km.}\\
K &= 7\cdot 87 \text{ km.}\\
e &= \cdot 072\\
\omega &= 141^\circ\cdot 80\\
T &= 2{,}418{,}249\cdot 118 \text{ J. D.}
\end{aligned}$$

It is rather strange that $e$ and $\omega$ should have come back to so nearly the original values. $\Sigma pvv$ was reduced from 72·5 to 69·5. The agreement between computed and observation equation residuals was bad and a third solution was made for the sake of completion.

The new observation equations follow:—

TABLE VII.

OBSERVATION EQUATIONS (3)

| No. | $x$ | $y$ | $z$ | $u$ | $v$ | $-n$ | Weight. |
|---|---|---|---|---|---|---|---|
| 1 | 1 | + ·504 | − ·299 | + ·783 | − ·718 | − ·050 | 3·0 |
| 2 | 1 | + ·843 | − ·956 | + ·410 | − ·393 | − ·450 | 1·0 |
| 3 | 1 | + ·943 | − ·789 | − ·042 | − ·002 | + 2·850 | 1·0 |
| 4 | 1 | + ·885 | − ·224 | − ·382 | + ·312 | + 0·720 | 2·0 |
| 5 | 1 | + ·787 | + ·256 | − ·581 | + ·512 | − 3·360 | 2·0 |
| 6 | 1 | + ·364 | + ·999 | − ·951 | + ·937 | + 0·820 | 1·5 |
| 7 | 1 | − ·580 | − ·175 | − ·896 | + ·971 | + 2·600 | 1·0 |
| 8 | 1 | − 1·048 | − ·926 | − ·178 | + ·151 | − 5·070 | 1·0 |
| 9 | 1 | − ·978 | − ·094 | + ·343 | − ·415 | + 1·260 | 2·0 |
| 10 | 1 | − ·658 | + ·814 | + ·754 | − ·796 | + 0·650 | 1·5 |
| 11 | 1 | − ·236 | + ·928 | + ·939 | − ·919 | − 0·400 | 1·5 |

The corresponding normal equations were:—

$$\begin{array}{rrrrrr}
17\cdot 5x & +2\cdot 254y & +0\cdot 245z & +1\cdot 515u & -1\cdot 776v & -1\cdot 375=0\\
 & 9\cdot 430y & -1\cdot 317z & -1\cdot 663u & +1\cdot 656v & -0\cdot 489=0\\
 & & 6\cdot 728z & -\ \cdot 127u & +\ \cdot 065v & +1\cdot 652=0\\
 & & & 7\cdot 578u & -7\cdot 394v & +1\cdot 371=0\\
 & & & & 7\cdot 262v & -1\cdot 073=0
\end{array}$$

Corrections resulting from the solution of these equations were:—

$$\begin{aligned} \delta\gamma &= \pm \cdot 00 \text{ km.} \\ \delta K &= \pm \cdot 00 \text{ km.} \\ \delta e &= -\cdot 038 \\ \delta\omega &= -42^\circ \cdot 62 \\ \delta T &= -\cdot 810 \text{ days.} \end{aligned}$$

Hence the finally accepted elements:—

$$\begin{aligned} P &= 6\cdot 951 \text{ days} \\ K &= 7\cdot 87 \text{ km.} \\ \gamma &= 15\cdot 40 \text{ km.} \\ e &= \cdot 034 \\ \omega &= 99^\circ \cdot 18 \\ T &= 2{,}418{,}248\cdot 308 \text{ J. D.} \end{aligned}$$

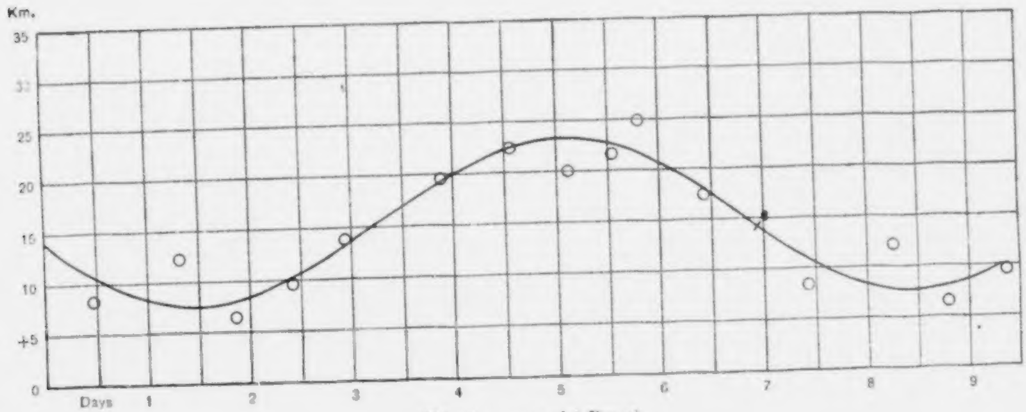
A summary follows showing results of the various solutions made in the determination. The probable errors are added in the last column.

SUMMARY.

| | Element. | Preliminary. | After 1st Solution. | New Preliminary | After 2nd Solution. | After 3rd Solution. |
|---|---|---|---|---|---|---|
| $P$ | Period.............. | 6·951 days | 6·951 days | 6·951 days | 6·951 days | 6·951 days |
| $K$ | Half-Amplitude...... | 7·75 km. | 7·75 km. | 7·75 km. | 7·87 km. | 7·87 km. ± 0·80 |
| $\gamma$ | Vel. of system....... | 15·92 km. | 15·40 km. | 15·06 km. | 15·40 km. | 15·40 km. ± 0·60 |
| $e$ | Eccentricity......... | ·1 | −·01 | ·05 | ·072 | ·034 ± ·114 |
| $\omega$ | Angular distance of Periastron from ascending node...... | 150° | 127°·53 | 60° | 141°·80 | 99°·18 ± 15°·49 |
| $T$ | Time of Periastron passage............... | 2,418,249·349 J.D. | ....248·853 | ....247·607 | ....249·118 | ..249·308 ± 1·575 |
| $a \sin i$ | ½ Major axis × sine of inclin............. | ............ | ............ | ............ | ............ | 75.,800 km. |
| | Prob. Error of Nor. Place, Wt. Unity.... | ............ | ............ | ............ | ............ | ± 2·3 km. |
| | $\Sigma pvv$............... | 74·7 | 73·2 | 72·2 | 69·5 | 68·2 |

After the completion of the orbit determination from the calcium lines, the results from the broad lines were reviewed. The diffuseness of the lines, however, and consequent uncertainty of the measures from them made it quite impossible to secure any reliable information from them. Some information in regard to these lines would have been very interesting, but it seems that so far we must be content with the one fact which seems assured — the broad lines show a much higher positive velocity than the *H* and *K* lines.

Dominion Observatory,
Ottawa,
June 1912.




Velocity curve of ξ Persei.